ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 612295

Proj. ECN

2. ECN Category (mark one) Supplemental [x] Direct Revision [x] Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	3. Originator's Name, Organization, MSIN, and Telephone No. J. G. Field, LMHC, R2-12, 376-3753	4. USQ Required? [] Yes [X] No	5. Date 7/23/97
	6. Project Title/No./Work Order No. Tank 241-B-104	7. Bldg./Sys./Fac. No. NA	8. Approval Designator NA
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.) WHC-SD-WM-ER-552, Rev. 0	10. Related ECN No(s). NA	11. Related PO No. NA

12a. Modification Work	12b. Work Package No.	12c. Modification Work Complete	12d. Restored to Original Condition (Temp. or Standby ECN only)
[] Yes (fill out Blk. 12b) [X] No (NA Blks. 12b, 12c, 12d)	NA	NA Design Authority/Cog. Engineer Signature & Date	NA Design Authority/Cog. Engineer Signature & Date

13a. Description of Change — 13b. Design Baseline Document? [] Yes [X] No

Add Appendix C, Evaluation to Establish Best-Basis Inventory for Single-Shell Tank 241-B-104.

14a. Justification (mark one)

Criteria Change	[]	Design Improvement	[]	Environmental	[]	Facility Deactivation	[]
As-Found	[X]	Facilitate Const	[]	Const. Error/Omission	[]	Design Error/Omission	[]

14b. Justification Details

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities. As part of this effort, an evaluation of available information for single-shell tank 241-B-104 was performed, and a best-basis inventory was established. This work follows the methodology that was established by the standard inventory task.

15. Distribution (include name, MSIN, and no. of copies)

Central Files	A3-88	K. M. Hall	R2-12
DOE Reading Room	H2-53	K. M. Hodgson	R2-11
TCSRC	R1-10	B. A. Higley	H5-49
File	H5-49	J. Jo	R2-12
J. G. Field	R2-12		
M. J. Kupfer	H5-49		
M. D. LeClair (3)	H0-50		

RELEASE STAMP
AUG 25 1997
DATE: HANFORD RELEASE
STA: 34 ID: 67

A-7900-013-2 (05/96) GEF095

A-7900-013-1 (06/92)

ENGINEERING CHANGE NOTICE

1. ECN (use no. from pg. 1)
612295

16. Design Verification Required	17. Cost Impact				18. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[] Yes	Additional	[] $	Additional	[] $	Improvement	[]
[X] No	Savings	[] $	Savings	[] $	Delay	[]

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]	Tickler File	[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
NA		

21. Approvals

	Signature	Date		Signature	Date
Design Authority			Design Agent		
Cog. Eng.	M. J. Kupfer M J Kupfer	7-29-97	PE		
Cog. Mgr.	K. M. Hodgson K. M. Hodgson	7/28/97	QA		
QA			Safety		
Safety			Design		
Environ.			Environ.		
Other	J. Jo JJo	7-29-97	Other		

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

Tank Characterization Report for Single-Shell Tank 241-B-104

J. G. Field and B. A. Higley
Lockheed Martin Hanford Corporation, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 612295 UC: 721
Org Code: 74610 Charge Code: N4G3A
B&R Code: EW3120074 Total Pages: 127 gm

Key Words: TCR, Best-basis inventory

Abstract: An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities. As part of this effort, an evaluation of available information for single-shell tank 241-B-104 was performed, and a best-basis inventory was established. This work follows the methodology that was established by the standard inventory task.

8/25/97
Release Approval Date

AUG 25 1997
DATE: HANFORD
STA: 34 RELEASE ID: 67
Release Stamp

Approved for Public Release

RECORD OF REVISION	(1) Document Number WHC-SD-WM-ER-552	Page 1

(2) Title
Tank Characterization Report for Single-Shell Tank 241-B-104

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
		(5) Cog. Engr.	(6) Cog. Mgr. Date
0	(7) Initially released 3/28/96 on EDT 615358.	J. G. Field	J. G. Kristofzski
0A RS	Incorporate per ECN-612295.	M. J. Kupfer	K. M. Hodgson 7-28-97
		M J Kupfer 7-29-97	

A-7320-005 (08/91) WEF168

APPENDIX C

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-B-104

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APPENDIX C

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE SHELL TANK 241-B-104

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of available information for single-shell tank 241-B-104 was performed, and a best-basis inventory was established. This work, detailed in the following sections, follows the methodology that was established by the standard inventory task.

The following evaluation provides a best-basis inventory estimate for chemical and radionuclide components in tank 241-B-104.

C1.0 CHEMICAL INFORMATION SOURCES

Two core samples were obtained and analyzed in 1995. A sample-based inventory was prepared based on the core sample analytical results, a waste density of 1.38 g/mL, and a waste volume of 1,400 kL. The Hanford Defined Waste (HDW) model (Agnew et al. 1997a) provides tank content estimates, derived from process flowsheets and waste volume records.

C2.0 COMPARISON OF COMPONENT INVENTORY VALUES

The sample-based inventory estimate, and the inventory estimate from HDW model (Agnew et al. 1997a) for tank 241-B-104 are shown in Table C2-1. (The chemical species are reported without charge designation per the best-basis inventory convention). The waste solids volume used to generate both estimates is 1,400 kL. The estimates, however, use different waste densities. The sample-based inventory used a bulk density of 1.38 g/mL and the HDW model uses a waste density of 1.35 g/mL, resulting in a modest difference for analytes of roughly the same concentration. In general, the two estimates agree, within a factor of two. Analytes such as, Cl, Cr, NO_3, and Si vary by a factor of about 3. The SO_4 inventory is approximately 5 times lower using the HDW model estimate and the Ca inventory is approximately a factor of 10 higher.

Table C2-1. Sample- and Hanford Defined Waste Model-Based Inventory Estimates for Nonradioactive Components in Tank 241-B-104.

Analyte	Sampling inventory estimate[a] (kg)	HDW model inventory estimate[b] (kg)	Analyte	Sampling inventory estimate[a] (kg)	HDW model inventory estimate[b] (kg)
Al	3,560	5,470	Density (kg/L)	1.38	1.35
Bi	22,100	19,600	NO_2	4,730	9,880
Ca	630	6,240	NO_3	560,000	196,000
Cl	4,080	1,870	P as PO_4	101,000	134,000
Cr	990	317	Si	11,000	3,890
F	6,680	3,980	S as SO_4	42,100	8,200
Fe	20,800	32,500	U_{TOTAL}	<3,700	24,900
Na	226,000	186,000	H_2O (wt%)	46.9	63.4

HDW = Hanford Defined Waste
[a]Appendix A
[b]Agnew et al. (1997a).

C3.0 COMPONENT INVENTORY EVALUATION

The following evaluation of tank contents was performed in order to identify potential errors and/or missing information that could influence the sample-based and HDW model component inventories.

C3.1 CONTRIBUTING WASTE TYPES

Tank 241-B-104 was put into service in August 1946, as the first tank in the 241-B-104, 241-B-105, and 241-B-106 cascade. The cascade received second-cycle $BiPO_4$ process (2C) waste from B Plant. Waste began overflowing to tank 241-B-105 in February 1947, and tank 241-B-105 overflowed to tank 241-B-106 in August 1947. After tank 241-B-106 was filled in May 1948, supernatants from the 241-B-104 tank cascade were pumped to cribs. In July 1950, the B Plant 2C waste was diverted back to the 241-B-110 tank cascade.

Starting in the first quarter of 1952 tank 241-B-104 reportedly began receiving first-cycle decontamination $BiPO_4$ process (1C) waste from B Plant. Supernatants were removed to tank 241-B-106 in the third quarter of 1950, and evaporator bottoms were routed to the tank beginning in December 1952. Initial evaporator bottoms were concentrated 1C waste supernatant and later Tri-Butyl Phosphate (TBP) process concentrates.

The current waste volumes for tanks in the 241-B-104 cascade are shown in Table C3-1. Agnew et al. (1997a) is used to partition the waste volume between sludge and saltcake inventories.

Table C3-1. Waste Inventory of the 241-B-104, 241-B-105, and 241-B-106 Tank Cascade.

Tank	241-B-104	241-B-105	241-B-106
Sludge volume[a] (kL)	1,170	106	0
Saltcake volume[a] (kL)	230	492	439
Supernatant volume[b] (kL)	4	0	4
Drainable liquid volume[b] (kL)	174	87	23

[a] Agnew et al. (1997a)
[b] Hanlon (1997).

The types of solids accumulated in tank 241-B-104 reported by various authors is compiled in Table C3-2.

Table C3-2. Expected Solids for Tank 241-B-104.

Reference	Waste type
Anderson (1990)	2C, 1C, EB, NCPLX
Historical Tank Content Estimate (Brevick 1997)	2C, 1C, Unknown, B SltCk
Sort On Radioactive Waste Type model (Hill et al. 1995)	2C, EB, TBP, 1C
Waste Status and Transaction Record Summary (Agnew et al. 1997b)	2C1, 2C2, 1C2, BSltCk
Hanford Defined Waste model (Agnew et al. 1997a)	2C1, 2C2, 1C2, BSltCk

BSltCk = Saltcake waste generated from the 242-B Evaporator
EB = Evaporator bottoms
NCPLX = Non-complexed waste term applied to all Hanford Site liquors not identified as complexed
TBP = Tri-butyl phosphate process concentrates.
1C = First-cycle decontamination $BiPO_4$ process
1C2 = First-cycle decontamination waste from the $BiPO_4$ process, 1952 through 1956
2C = Second-cycle waste from BiO_4 process
2C1 = Second-cycle waste from BiO_4 process, 1944 through 1951
2C2 = Second-cycle waste from BiO_4 process, 1952 through 1956

C3.2 EVALUATION OF PROCESS FLOWSHEET INFORMATION

An estimate of the amount of 2C waste discharged to each cascade can be made from the fuel process history and flowsheet information. The technical manual flowsheet is applied to the first time period and the Schneider (1951) flowsheet was applied to the last two time periods (Kupfer et al. 1997). The results of this calculation are shown in Table C3-3.

Table C3-3. Disposition of B Plant 2C Waste.

Time period	May 1945 to August 1946	September 1946 to June 1950	July 1950 to August 1952	Total
Cascade	241-B-110	241-B-104	241-B-110	B Plant
Fuel processed (MTU)	631.1	1,311.8	822.8	2,765.8
Waste Component (kg)				
Bi	8,990	23,900	15,000	47,900
Cr	421	1,190	748	2,360
F	19,900	54,100	33,900	108,000
Fe	8,610	31,000	19,400	59,000
Na	283,000	675,000	423,000	1.38 E+06
NO_3	364,000	1.13 E+06	708,000	2.20 E+06
Si	4,970	13,100	8,200	26,300
PO_4	235,000	423,000	265,000	923,000
SO_4	29,500	107,000	66,800	203,000

Comparison of the calculated discharge to the 241-B-104 tank cascade with the sample-based inventory in tank 241-B-104 is shown in Table C3-4. Table C3-4 indicates that most of the 2C sludge discharged to the 241-B-104 tank cascade collected in tank 241-B-104 and very little of the 2C solids overflowed to tank 241-B-105. Looking at the species most likely to fully precipitate, Bi, Cr, Fe, Si, PO_4, and SO_4, good agreement can be seen between the flowsheet based estimate and the sample-based estimate. Extrapolation of tank 241-B-104 sample-based data for bismuth to the sludge in tank 241-B-105 (106 kL [28 kgal]) implies that the total bismuth in the 241-B-104 tank cascade is about 25,000 kg.

Table C3-4. Comparison of Tank 241-B-104 Inventory Estimates and the 241-B-104 Tank Cascade Receipts.

Waste component	Sample-based inventory estimate (kg)	HDW model inventory estimate (kg)	Calculated inventory discharged to cascade (kg)
Bi	22,100	19,600	23,900
Cr	990	317	1,190
F	6,680	3,980	54,100
Fe	20,800	32,500	31,000
Na	226,000	186,000	675,000
NO_3	560,000	196,000	1.13 E+06
Si	11,000	3,890	13,100
PO_4	101,000	134,000	423,000
SO_4	42,100	8,200	107,000

HDW = Hanford Defined Waste.

Sample results were obtained for two full cores. Because no vertical or horizontal stratification was observed, it may be concluded that the B saltcake waste may have mixed with the 2C waste. This may have occurred if the evaporator bottoms waste was introduced as a hot concentrated liquor rather than a salt slurry. Alternatively, there may be little or no B saltcake in the tank.

C3.3 DOCUMENT ELEMENT BASIS

In general, reasonably good agreement was found between sample results, the HDW model, and flow sheet based estimates. The primary differences were for calcium and sulfate, which varied by factors of roughly 10 and 5 respectively.

Bismuth, chromium, iron, and silicon in the flowsheet analysis were assumed to fully precipitate. The flowsheet analysis for these elements reconciles better with the sample-based estimate than does the HDW model.

Fluoride, sodium, nitrate, and nitrite inventories cannot be reconciled because these components are relatively soluble. The uncertainties involved in the compound interactions of cascading the waste and addition of evaporator bottoms cannot be estimated with any degree of accuracy. The best source of information with respect to these compounds is the sample-based estimate.

Once the best-basis inventories were determined, the hydroxide inventory was calculated by performing a charge balance with the valences of other analytes. In some cases this approach requires that other analyte (e.g., sodium or nitrate) inventories be adjusted to achieve the charge balance. During such adjustments the number of significant figures is not increased. This charge balance approach was consistent with that used by Agnew et al. (1997a). The HDW model value was used for NO_3 to achieve the charge balance, and a value for hydroxide. The calculated total hydroxide inventories based on sample data (HDW data for NO_3) and the HDW model were 49,600 kg and 51,200 kg.

C4.0 DEFINE THE BEST-BASIS AND ESTABLISH COMPONENT INVENTORIES

The results from this evaluation support using the sampling data for tank 241-B-104 for the following reasons:

Core sample data from two widely spaced risers with multiple sampling of segments was used to estimate the component inventories.

- The sample-based inventory reconciles with the assumption that the primary source of sludge is bismuth phosphate 2C waste.
- The sample-based inventory with respect to 2C waste, reconciles with the flowsheet analysis of insoluble species.
- Evidence of 1C waste being a significant contributor to tank 241-B-104 is lacking. Most of the bismuth can be accounted for by 2C waste. The tank process history (Agnew et al. 1997b) indicates that 1C waste was not added to the 241-B-104 cascade until the first quarter of 1952. Generation of 1C waste ceased with the last receipt of fuel in June 1952.

Best-basis inventory estimates for tank 241-B-104 are presented in Tables C4-1 and C4-2. The projected inventory is based on a waste density of 1.38 g/mL. The inventory values reported in Tables C4-1 and C4-2 are subject to change. Refer to the Tank Characterization Database for the most current inventory values.

Best-basis tank inventory values are derived for 46 key radionuclides (as defined in Section 3.1 of Kupfer et al. 1997), all decayed to a common report date of January 1, 1994. Often, waste sample analyses have only reported ^{90}Sr, ^{137}Cs, $^{239/240}$Pu, and total uranium (or total beta and total alpha), while other key radionuclides such as ^{60}Co, ^{99}Tc, ^{129}I, ^{154}Eu, ^{155}Eu, and ^{241}Am, etc., have been infrequently reported. For this reason it has been necessary to derive most of the 46 key radionuclides by computer models. These models estimate radionuclide activity in batches of reactor fuel, account for the split of radionuclides to various separations plant waste streams, and track their movement with tank waste transactions. (These computer models are described in Kupfer et al. 1997, Section 6.1 and in Watrous and Wootan 1997.) Model generated values for radionuclides in any of 177 tanks are reported in the HDW Rev. 4 model results (Agnew et al. 1997a). The best-basis value for any one analyte may be either a model result or a sample or engineering assessment-based result if available. (No attempt has been made to ratio or normalize model results for all 46 radionuclides when values for measured radionuclides disagree with the model.) For a discussion of typical error between model derived values and sample derived values, see Kupfer et al. 1997, Section 6.1.10.

Table C4-1. Best-Basis Inventory Estimate for Nonradioactive Components in Tank 241-B-104 (Effective May 31, 1997). (2 sheets)

Analyte	Total inventory (kg)	Basis (S, M, E or C)[1]	Comment
Al	3,560	S	
Bi	22,100	S	
Ca	630	S	
Cl	4,080	S	
TIC as CO_3	11,200	M	
Cr	990	S	
F	6,680	S	
Fe	20,800	S	
Hg	9.56	M	
K	416	M	
La	0	M	
Mn	0	M	
Na	226,000	S	
Ni	200	M	
NO_2	4,730	S	
NO_3	196,000	M	Adjusted for charge balance calculations. Sample value was 560,000 kg
OH	49,600	C	Mass balance calculation
Pb	0	M	
P as PO_4	101,000	S	
Si	11,000	S	
S as SO_4	42,100	S	
Sr	0	M	
TOC	74.3	M	
U_{TOTAL}	<3,700	S	

Table C4-1. Best-Basis Inventory Estimate for Nonradioactive Components in Tank 241-B-104 (Effective May 31, 1997). (2 sheets)

Analyte	Total inventory (kg)	Basis (S, M, E or C)[1]	Comment
Zr	13.8	M	

[1]S = Sample-based
M = Hanford Defined Waste model-based
E = Engineering assessment-based
C = Calculated by charge balance; includes oxides as hydroxides, not including CO_3, NO_2, NO_3, PO_4, SO_4, and SiO_3.

Table C4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-B-104, (Effective May 31, 1997) Decayed to January 1, 1994. (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	1.3	M	
^{14}C	0.209	M	
^{59}Ni	0.168	M	
^{60}Co	0.0485	M	
^{63}Ni	15.2	M	
^{79}Se	0.044	M	
^{90}Sr	10,200	M	
^{90}Y	10,200	M	
^{93m}Nb	0.176	M	
^{93}Zr	0.209	M	
^{99}Tc	1.45	M	
^{106}Ru	2.06 E-08	M	
^{113m}Cd	0.514	M	
^{125}Sb	0.0453	M	
^{126}Sn	0.0663	M	
^{129}I	0.00273	M	
^{134}Cs	0.00145	M	
^{137m}Ba	18,300	M	
^{137}Cs	19,400	M	
^{151}Sm	164	M	
^{152}Eu	0.0446	M	
^{154}Eu	0.879	M	
^{155}Eu	3.28	M	
^{226}Ra	1.17 E-05	M	
^{227}Ac	6.00 E-05	M	
^{228}Ra	1.60 E-10	M	
^{229}Th	3.12 E-08	M	

Table C4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-B-104, (Effective May 31, 1997) Decayed to January 1, 1994. (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{231}Pa	1.31 E-04	M	
^{232}Th	5.93 E-11	M	
^{232}U	1.90 E-04	M	
^{233}U	8.78 E-06	M	
^{234}U	8.17	M	
^{235}U	0.361	M	
^{236}U	0.0815	M	
^{237}Np	0.00895	M	
^{238}Pu	0.443	M	
^{238}U	8.31	M	
^{239}Pu	86.7	M	
^{240}Pu	6.44	M	
^{241}Am	0.414	M	
^{241}Pu	14.1	M	
^{242}Cm	8.32 E-04	M	
^{242}Pu	6.14 E-05	M	
^{243}Am	2.90 E-06	M	
^{243}Cm	1.71 E-05	M	
^{244}Cm	6.87 E-05	M	

[1]S = Sample-based
M = Hanford Defined Waste model-based
E = Engineering assessment-based.

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